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CONSTRUCTION OF THE ELIZABETH RIVER TRENCH-TYPE TUNNEL

by Joseph Peraino, A.M., ASCE

CONSTRUCTION DIVISION

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CONSTRUCTION OF THE ELIZABETH RIVER TRENCH-TYPE TUNNEL

Joseph Peraino
Chief Designing Engineer
New York Marine and Heavy Construction Division
Merritt-Chapman & Scott Corporation

Some of the most interesting early chapters of the Elizabeth River Tunnel story unfolded at Sparrows Point, Md., on the upper reaches of the Chesapeake Bay, opposite Baltimore, almost 200 miles from the tunnel site at Norfolk, Va.

It was there, on the shipways of the Bethlehem Steel Company's Sparrows Point yard, that Merritt-Chapman & Scott arranged for the construction of the seven huge tubes of double shelled steel casing that were to serve as the core of the tunnel's underwater section beneath the Elizabeth River.

The story of the tunnel that went into service on May 23, 1952, as part of a bridge tunnel expressway providing the first direct traffic link between Norfolk and Portsmouth, Va., can perhaps best be told by following the course of one of those sections from initial construction ashore until--fitted with an inner ring of concrete and stretch of roadway slab--it was sunk and locked into position in a trench dredged across the river bottom.

Work on the approaches naturally entailed special problems on either shore, but none matched those involved in exactly positioning the tubes that were to comprise the underwater link.

Construction of the bridge-tunnel expressway that brought to reality the 25-year-old dream of a direct vehicular link between Norfolk and Portsmouth to end their dependence on ferries and a roundabout bridge route was initiated in February, 1950 with award by the Elizabeth River Tunnel Commission of a joint contract to Merritt-Chapman & Scott Corporation and the Tidewater Construction Company.

Under the joint contract, Merritt-Chapman & Scott was to build the tunnel, linking Portsmouth and Berkley, beneath the South Branch of the Elizabeth River, and Tidewater was to build the bridge, linking Berkley and Norfolk, over the East Branch of the river. Parsons, Brinckerhoff, Hall & Macdonald were designated as consulting engineers for the tunnel phase of the project, with the J. E. Greiner Company serving in similar capacity for the bridge. Approximately 2,135 feet long from abutment to abutment, the bridge provides 150 feet of horizontal clearance at the channel, and 45 feet of vertical clearance when its double-leaf rolling lift bascule is closed.

The Elizabeth River Tunnel is the fifth trench-type vehicular underwater crossing to be built in the United States and the third to be constructed by Merritt-Chapman & Scott. It runs approximately 3,400 feet from portal to portal, of which 2,100 feet were precast tubes.

Into the construction of that underwater section went seven double-shelled steel casings, each approximately 300 feet long. The typical story of one of these sections starts on a shipway at Sparrows Point, Md., where approximately 650 tons of prefabricated steel went into its all welded construction. Each was 35 feet, four inches, across the width of its outer, octagonal-shaped shell, which, fabricated of one-quarter inch plate, encircled a

circular inner shell of 5/16-inch plate with a diameter of 31 feet, four inches.

The outer shell was connected to the inner shell by transverse frames, spaced 12 feet on centers. Since the upper quadrant of the section between the shells was to be capped with structural concrete, the top plate was eliminated from the octagonal-shaped shell.

The main body of each double-shelled section was approximately 292 feet long and was faced at each end by a rectangular dam plate of 5/8-inch plate, 35-1/2 feet wide by 36 feet high. The interior face of the dam plate, which served as a bulkhead, was reinforced with wide flange beams. A 4',3" collar was welded to its outer face as an extension of the inner shell.

During construction on the shipways, a webbing of reinforcing steel was welded to the interior face of the circular shell, exclusive of the part that extended beyond the dam plate. This reduced to a minimum the handling of reinforcing steel at the job site.

Fitted with a temporary launching bow and ballasted with approximately 1,000 tons of concrete placed in its "keel" between the outer and inner shells, the tube was then sent down the ways like any ship. Drawing approximately 8'-6" of water, the section was then taken in tow by a tug for the 185 mile trip down the Chesapeake Bay to Merritt-Chapman & Scott's "shape-up" dock at the tunnel site. On arrival, the section was warped into position alongside a pair of finger piers. First step, with the section still afloat, was to fit it with an 18-inch inner ring of concrete and a 14-inch thick stretch of roadway slab 22 feet wide.

Concrete was batched and mixed by one of Merritt-Chapman & Scott's floating concrete plants moored adjacent to the pier. From there, concrete was fed to a pumpcrete plant ashore, and was then sent out over the piers and into the tube through eight-inch lines. Concrete was placed in the tube by elephant trunks through six rectangular hatchways spaced along the top of the inner shell.

Since the tunnel section was afloat throughout this operation, care had to be maintained to insure stability. This was achieved by carefully balancing the successive steps followed in building the inner ring of concrete over the webbing of reinforcing steel. In each case, the entire stretch of invert was built first by screeding it in place. Next to be built were the roadway haunches, which encased water mains and drains; the roadway slab, side walls and arch.

Key problem in each of the four successive concreting operations following construction of the invert was to avoid any excessive strain on the steel casing. This was accomplished by use of a specially designed system of four travelling forms which were devised so that they could be lowered sectionally through the 3'-7" by 5'-7" hatchways in the top of the inner shell. Once inside the tube, they were assembled in four 37-1/2-foot sections.

To keep the section in trim, each successive concreting operation within the tube was started simultaneously at the quarter points of the interior section, with two forms teamed on each side to concrete a 75-foot stretch. When this first pour was completed, two forms were moved toward the center and two toward each end, thereby keeping the tube in trim. Following construction of the haunches, forms were dismantled and, using the same travellers, others were installed to carry through construction of the roadway slab. The same procedure was successively followed in placing the sidewalls and arch. During placement of the arch, two hatchways were left open to permit final removal of the dismantled forms. Concreting was then completed by the use of suspended wooden forms, after which all hatches

atop the tube were sealed by welded plate.

With all interior concrete in place and the shell completely sealed, next step was to place sufficient tremie concrete in the "side pockets" between the inner and outer casings to insure stability before placing the structural concrete which forms the cap along the upper quadrant of the section.

As this "shape-up" concreting progressed, the once extremely buoyant tube sank deeper in the water. Once the concrete cap was in place, the section drew approximately 33 feet, with only about 2-1/2 feet of free board. Sluggishly afloat, it was then towed out to a point on the river exactly above its final position in the trench, which meanwhile had been dredged across the river bed.

Preparatory to the sinking operation, tall target masts had been fitted atop each end of the tube. Two Merritt-Chapman & Scott floating derricks were stationed at either end, their slings hooked into plate shackles built into the top of the tube. A third derrick was used to maneuver the hopper through which additional tons of tremie concrete were placed in the open spaces still remaining in the "sidepockets" running the length of the section.

Sinking deeper with each additional ton of concrete, the tube gradually reached the point of negative buoyancy. If weighed in the dry at that time, it would have tipped the scales at approximately 9,100 tons, including 650 tons of steel and 8,450 tons of built in concrete. Concreting continued until, after having lost all buoyancy the section weighed approximately 100 tons under water. The two derricks then gently lowered the tube until it came to rest on the blanket of sand, screeded to proper grade, which had been prepared for it on the trench bottom. As it went down, transitmen ashore kept the target constantly in their sight to insure perfect alignment and grade.

The screeding device used to bring the trench to final grade was suspended by cables from a steam powered car travelling on inclined tracks mounted on a barge at an angle paralleling the grade of the trench. As the car moved back and forth, the drag brought the trench to exact grade. Once the stretch of trench beneath the barge was screeded to correct elevation, the barge was moved ahead and, after adjusting the length of the drag's cables, the operation was repeated.

The first of the seven sections was sunk on the Berkley side of the river. After underwater examination by divers to insure exact placement, additional tremie concrete was added to keep it from refloating due to possible changes in the specific gravity of the river.

Following the same procedure, Tube 2 was then sunk into position and locked to Tube 1. Half-circle, 18-inch hood plates projected beyond the collars of each section. On one end they were on the top of the collar, on the other at the bottom. At each end of the half circle, the hooded plates were fitted with a slotted flange. As each tube section was positioned next to the other on the river bottom, the hood plates formed a complete circle, bringing the slotted flanges into alignment. After a river bottom inspection to insure exact placement, M.-C. & S. divers drove five-inch pins through the slotted flanges, bolting the sections together. The divers then further locked the sections together by taking up on five pairs of steamboat ratchets fitted around the circumference of the collars.

Tube 3 was similarly placed and locked into position. That done, a collar of tremie concrete was placed around the joint between Tubes 1 and 2. Backfill was then placed over the first two tubes, with care being exercised to see that it did not cover either the shoreside end of Tube 1 or the joint between Tubes 2 and 3. This procedure was repeated as Tubes 4 and 5 were positioned.

The fact that the Elizabeth River crossing is one of the dryest tunnels ever built is due in good part to the careful planning--jointly carried out by the engineering staffs of the consulting engineers and the contractor--that went into construction of the tube joints.

As a first step in this planning, continuous strips of steel sheetpiling interlock were welded to the vertical edges of the dam plates. As each tube was set and locked to its neighbor, a half circle of 1/4-inch plate, 37'-0" high and edged with steel sheet piling interlock was fitted into the interlocks along one side of both dam plates, and was lowered to the river bottom. Another was similarly slotted into position between the dam plates on the other side of the tube. This design provided vertical closures that acted in tension as the tremie collar was placed around the joint.

Because of his broad background of experience in the field of marine construction, the contractor elected to make a subaqueous juncture between the shore end of the Tube 7 and the 625-foot cut and cover section on the Portsmouth side. While tubes 1 through 5 had been placed in sequence from the Berkley side, this meant that Tube 7, which was to be positioned in a wet trench leading to the cut and cover approach, had to be placed before Tube 6. If Tube 6 were already in place, there would be no room to maneuver Tube 7 into the wet trench.

As a first step, a 50-foot wide trench was excavated for the cut and cover section, starting at a point approximately 225 feet inshore. Sides of the trench, which ranged from 30 to 60 feet in depth, were sheeted with master piles and wood lagging, shored throughout. Deep well pumps controlled seepage. Before construction of the trench could be started, a 106-foot railroad bridge had to be built to provide uninterrupted service for the Seaboard Airline, whose railroad tracks crossed the cut and cover section diagonally.

A transition joint, consisting of a bulkheaded telescopic tube which matched the diameter of the collar of Tube 7, was erected in the dry at the river end of the cut and cover section. The rim of the telescopic tube was fitted with a channel section to receive the collar of Tube 7, and was rigged with steamboat ratchets and lugs similar to those on the tube section.

While the cut and cover section was under construction, a wet trench was dredged between the shore and a dike which was left to protect the outboard end of the cut and cover section. The wet trench, which finally ran 202 feet in length, was approximately 70 feet deep at the river end and approximately 60 feet deep at the inshore end. To support its sides, 36-inch wide flange beams were driven on approximately 31 inch centers. Thirty inch wide flange beams were then driven between the webs of the 36-inch beams, thereby forming solid retaining walls of steel. This sheeting was braced by two sets of transverse shores, one above water, the other beneath the surface. Four 60-foot diameter cells and steel sheetpile bulkhead were driven at the outer end of the trench to protect adjacent shoreside installations. The outboard face of the deepest cell was in approximately 70 feet of water.

Once this construction was completed, the cut and cover section was backfilled inshore of the transition joint. The original dike was then removed, providing a continuous wet trench between Tube 5 and the transition joint.

Tube 7 was then maneuvered so that its inboard end faced the wet trench, and was tremie concreted to a point of negative buoyancy. With a land crane pulling by cable on the inboard end and a floating derrick maneuvering the outboard end, the tube was then carefully warped into the trench. Since the

lower set of transverse shores provided only five feet of vertical clearance, extreme care had to be maintained to keep the tube in exact grade. There was always the danger that the sides of the wet trench would collapse if the tube hit and seriously damaged one of the shores.

Once Tube 7 was locked to the transition joint, Tube 6 was lowered into place and locked to Tube 5. With the telescopic transition joint providing the leeway, Tube 7 was then pulled back approximately 1'-6" and locked to Tube 6. With all joints concreted and backfill placed over the tubes, the subaqueous phase of the project was completed.

Meanwhile work had been going forward simultaneously at effecting a juncture between the inboard end of Tube 1 and the 610 foot section of cut and cover on the Berkley side. By throwing a dam across Tube 1 and dewatering the inboard area, this operation was carried out in the dry. Actually, the holing through operation was started on the Berkley side after the fifth tube has been positioned. Early work on the Berkley cut and cover section, incidentally, involved erection of a railroad trestle and bridge to permit uninterrupted service by the Norfolk and Southern railroad.

As indicated earlier, an 8' 6" space existed between the dam plates at each joint. This space within the collar was filled with water, which had to be removed before the bulkheads were holed through. Advance provision for dewatering had been made by installing two valves, one at the top of the bulkhead as an air relief valve, the other at the bottom for drainage. Once, drained, the two bulkheads were removed. The dismantled bulkheads were put into service as temporary bridges between the stretches of roadway which previously had been built within each section.

First, the joint was sealed from the inside by welding a closure plate across two T's flanking the joint. This formed an annular space, which was then grouted under pressure. This technique provided maximum assurance against seepage.

Reinforcing steel was then placed around the circumference of the collar, and was embedded in 18 inches of concrete to bring the inner face of the joint flush with the rest of the tube section. This concrete could now be trucked in. After the collar concrete had set, the temporary bridging was removed and forms were installed for placing the stretch of roadway slab across the joint.

While this work was going on, other crews, working their way in from the portal, were feeding utility lines through ducts in the sidewalls and placing concrete for the walkway and curbs. Still others were preparing the walls to receive the tile and electrical fixtures, and install hangers for the suspended ceiling, which provides a minimum vertical clearance of 14 feet. As the interior work moved forward from the Berkley side, other crews started in from the Portsmouth end. The last bulkhead removed was the one at the outboard end of Tube 7.

Erection of the ventilation building, located on the Portsmouth side, had meanwhile been going forward. From the time the first bulkhead was holed through, a constant supply of fresh air was maintained in the tunnel for the construction crews by means of a temporary system of exhaust fans under the roadway slab.

The permanent ventilation system is comprised of four giant fans which exhaust air from the tunnel through the spaces above the suspended ceiling and beneath the roadway slab. Fresh air enters the tunnel through the portals at atmospheric pressure.

Placement of the roadway wearing surface, a layer of macadam varying from 2-1/2 to 5 inches in depth, was left as the last step in construction of

the tunnel, after the various forms and scaffoldings used in other interior work had been removed.

Placed in actual construction on September 15, 1950 the tunnel was opened for traffic on May 23, 1952, for an elapsed time of 20 months and 8 days.

A fast review such as this necessarily can give only the highlights of the tunnel's construction story. It would not be complete, however, if it did not point out the construction economy, both in money and time, achieved by a trench-type tunnel as compared with a shield driven tunnel.

Perhaps the simplest way to emphasize that fact, is to say that there would be no tunnel under the Elizabeth River today if it had not been possible to construct it by the trench-type method. Had it been a question of using the shield driven technique, the cost of the project, which was financed by revenue bonds, would have been prohibitive.